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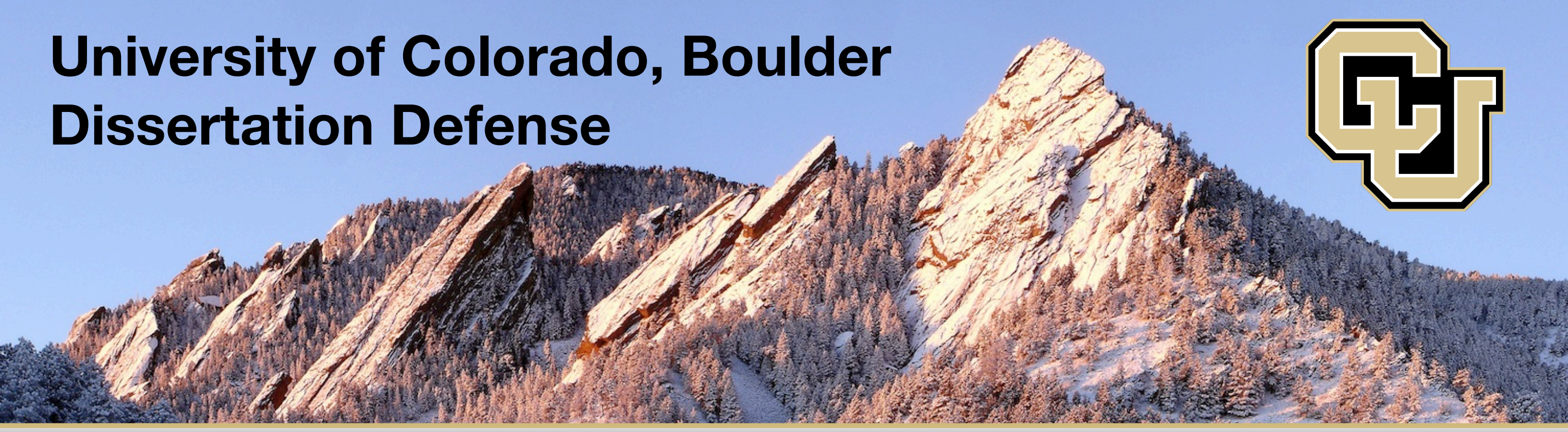

Tuesday, October 11, 2016
3:30pm-4:30pm (refreshments at 3:15pm)
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Coalescence, clustering, and chaotic stirring: The role of Lagrangian coherent structures in the mixing and unmixing of scalars

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Turbulent flows are renowned for their ability to efficiently dilute scalars due to rapid mixing. The structure of turbulent flows that leads to efficient mixing, however, has also been shown to organize scalars in specific regions of the flow. Due to structured stirring, initially distant reactive scalars that are separated by a third non-reactive fluid have been shown to organize in regions at times shorter than that required for dilution, leading to reaction enhancement. This thesis examines the coalescence of initially distant scalars using numerics, analytics, and experiments to infer the role that Lagrangian coherent structures (LCS) play in the coalescence process. In addition, scalar coalescence and clustering on an effectively compressible free-surface (such as the surface of the ocean) is examined to quantify whether non-divergence-free effects increase the likelihood of reaction enhancement. We show that LCS are responsible for coalescence in incompressible flows due to coherent stretching that attracts distant filaments. In non-divergence-free flows, the LCS has an additional dilatation component that 1) facilitates the coalescence process, which increases the likelihood of reaction enhancement, and 2) leads to the formation of clusters from initially well- mixed scalars. The instantaneous structure of turbulent flows, whether in an incompressible or compressible environment, is essential in facilitating the coalescence of initially distant scalars, which leads to reaction rates that can far exceed those from random diffusive mixing.